FAST GAMMA CORRECTION METHOD FOR IMAGE READING APPARATUS

Field of the invention

The present invention relates to a fast gamma correction method for image

5   reading apparatus, especially to a fast gamma correction method for image

reading apparatus with less storage space.

Background of the invention

The image reading apparatus such as scanner, digital still camera and

video camera become popular, as the Internet is prevalent. The image reading

10   apparatus have different mechanism and physical property with image output

apparatus such as display and printer. Therefore, the image data obtained from

the image reading apparatus generally requires correction such as gamma

correction to present picture with fidelity.

Provided that X denotes input pixel data and Y denotes output pixel data,

15   the Gamma correction can be expressed in the form $Y=X^{\gamma}$, or other empirical

curve. The function representation is hard to realize by hardware, look-up table

is often used to enhance processing speed. The size of the gamma correction

table depends on the resolution (bit number) of the input pixel data and output

pixel data. The gamma correction table requires 4K word storage space of

20   12-bit input data and 8-bit output data. The gamma correction table requires

64K word storage space of 16-bit input data and 8-bit output data, which is not

feasible for ordinary platform.

The applicability of the look-up table is also limited by data accessing

speed. The page mode accessing is not useful due to the randomness of pixel

data. The data accessing time is 120ns for external 60ns DRAM.

Summary of the invention

It is an object of the present invention to provide a gamma correction method for image reading apparatus with less storage space.

5   It is an object of the present invention to provide a gamma correction method for image reading apparatus with fast accessing speed.

To achieve above objects, the gamma correction method for image reading apparatus according to the present invention comprises following steps:

a. provided that the normalized output pixel data Y is quantified by n-bit,

10   the original 2^n intervals is reduced to M merged interval, wherein $M \leq 2^n$, the original correction function is represent by an approximated function with simple function form in each merged interval;

b. reading normalized input pixel data X and allocating the read data to a merged interval;

15   c. finding the normalized output pixel data Y by approximated function in the merged interval and the normalized input pixel data X.

The various objects and advantages of the present invention will be more readily understood from the following detailed description when read in conjunction with the appended drawing, in which:

20   **Brief description of drawing:**

Fig. 1 is an example with liner fitting function for gamma correction function;

Fig. 2 demonstrates interval mergence in the present invention;

Fig. 3 shows a block diagram to realize the gamma correction method

according to the present invention.

Detailed description of the invention

The gamma correction function is generally monotonic function, therefore, realistic gamma correction function can be approximated by a simple

5 function such as linear function or polynomial function is a specific interval. The gamma correction function has good approximation by prudently choosing interval and approximating function even though the gamma correction function is not monotonic function.

Fig. 1 shows a first example of gamma correction function approximated

10 by a linear function, wherein X denotes normalized input signal to be corrected and Y denotes normalized output signal to be corrected. The normalized output signal Y is quantified to 2 bit for illustration. The threshold values of Y coordinate are 0, 0.25, 0.5, 0.75, and 1. That is, the output between 0 and 0.25 is corresponding to Y_1 (code 00)，the output between 0.25 and 0.5 is

15 corresponding to Y_2 (code 01, etc. The solid line in this figure represents realistic gamma correction function and the dashed line in this figure represents approximated gamma correction function. The threshold values of X coordinate X_{T0}, X_{T1}, X_{T2}, X_{T3}, X_{T4} can be obtained by inversely mapping threshold values of Y coordinate 0, 0.25, 0.5, 0.75, 1 with respect to realistic gamma correction

20 function.

In the example shown in Fig. 1, the related interval of the input pixel data X is determined with reference to the threshold values of X coordinate X_{T0}, X_{T1}, X_{T2}, X_{T3}, X_{T4} and then an appropriate fitting function is used to obtain corresponding output pixel data Y. In the example shown in Fig. 1, two

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comparison steps are required if binary search is used. If the output pixel data Y is represented by n-bit, n times of comparison is required, which is time consuming. In the present invention, the 2^n intervals are merged to reduce search time.

5   The symbols used in the specification are list below for clarity:

m: resolution of input data

n: resolution of output data

$\{Y_0, Y_1...Y_{2^n-1}\}$: symbolic set of output data

$\{X_0, X_1...X_{2^m-1}\}$: symbolic set of input data

10     $\{T_0, T_1...T_{2^n}\}$: threshold set

Y=G(X): realistic color correction function

$F_{(h,k)}$ (.) fitting function in interval (T_h, T_k)

D(.): distortion measure function

Q(.): quantizer function

15   Provided $T_0=0$, $T_{2^n}=1$, which are boundary values of output pixel data and the thresholds $T_0, T_1...T_{2^n}$ divide the range of normalized output data into 2^n intervals. The normalized output data can be obtained with reference to the thresholds $Y_j=(T_j+T_{j+1})/2$，j=0, 1, 2 ..2^n-1 and the quantization of normalized output data is executed by following formula:

20     $Q(Y)=\min\{D(Y-Y_j) \mid Y_j, j=0\sim2^n-1\}$

The input thresholds can also be obtained by the output thresholds:

$\{G^{-1}(T_0), G^{-1}(T_1).... G^{-1}(T_{2^n})\}$

If the 2^n intervals are not merged, the related interval of the input data is found and then the output signal is obtained by the function relationship

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$Y=G(X)$. For example, for the input data $G^{-1}(T_j)<X< G^{-1}(T_{J+1})$, the output

signal corresponding to X is Y_j.

The present invention is characterized in that the 2^n intervals of the output

data are merged into a plurality of merged intervals, and the color correction

5 function in each merged interval can be approximated by a suitable fitting

function. For example, if the intervals between T_h to T_k are combined to a

merged interval and the color correction function in the merged interval is

approximated by a fitting function $F_{(h,k)}$ (.), which is a simple function such as a

linear function or exponential function.

10 Fig. 2 demonstrates interval mergence in the present invention, wherein

the fitting function $F_{(h,k)}$ is a linear function represented by dashed line and the

realistic color correction function is represented by solid line. In this example,

m=3 and n=2, and there are four intervals for the output data. When one tries to

combine interval (T_2, T_3) and (T_3, T_4), and approximates the color correction

15 function in the merged interval by a fitting function $F_{(2,4)}$ (.). The quantized

input data X4 has contradiction because $Q(F_{(2,4)}(X_4))=Y_2$ and $Q(G(X_4))=Y_3$.

Therefore, the interval (T_2, T_3) and (T_3, T_4) cannot be combined. On the

contrary, the combination of intervals (T_0, T_1) and (T_1, T_2) are safe. Therefore,

the intervals (T_0, T_1) and (T_1, T_2) can be combined into a merged (T_0, T_2), and

20 the color correction function in the merged interval is approximated by a fitting

function $F_{(0,2)}$ (.).

Hereinafter is the merging algorithm for intervals

step 0: set k=0 ;

step 1: set h=k ;

step 2: set=k+1 ;

step 3: if k=2^n , stop ;

step 4: if s is within (h,k), and all X_T, T=0..2^m-1, in ($G^{-1}(T_s)$, $G^{-1}(T_{s+1})$), are

equal to all X_T, T=0..2^m-1 in ($F^{-1}_{(h,k)}$ (T_s), $F^{-1}_{(h,k)}$ (T_{s+1})), back to

step 2 ;

step 5: merging (T_h, T_{h+1})~(T_{k-1}, T_k) into (T_h, T_k), and recoding $F_{(h,k)}$ (.) ;

step 6: back to step 1.

As can be seen from above algorithm, the criterion to validate the merged

interval is to check the consistence between the input data obtained by inverse

mapping all output data in the merged interval by realistic color correction

function and the input data obtained by inverse mapping all output data in the

merged interval by fitting function. If the validation is positive, the mergence is

allowable and next interval to the merged interval is tested for further

mergence.

Fig. 3 shows a block diagram to realize the gamma correction method

according to the present invention, wherein X denotes the normalized data to be

corrected and Y denotes the normalized data after correction. The block

diagram comprises a searching unit 102, a storage unit 104 and a curve fitting

and output mapping unit 106. The searching unit 102 is used to found the

related interval for the normalized input data X. The storage unit 104 is used to

store the merged interval (X_j, X_{j+1}), j=0..M-1. The curve fitting and output

mapping unit 106 is used to generate a fitting function corresponding to a

related interval and then maps the input data to a corresponding corrected

output data. For an input normalized data X to be corrected, the searching unit

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102 compares the input normalized data X with thresholds in the storage unit

104 and finds a related interval for the input normalized data X. The curve

fitting and output mapping unit 106 generates a fitting function corresponding

to the related interval and then maps the input data to a corresponding corrected

5   output data. Although the present invention has been described with reference

to the preferred embodiment thereof, it will be understood that the invention is

not limited to the details thereof. Various substitutions and modifications have

suggested in the foregoing description, and other will occur to those of ordinary

skill in the art. Therefore, all such substitutions and modifications are intended

10   to be embraced within the scope of the invention as defined in the appended

claims.